FERMILAB-EN-0101

BOOSTER-MAIN RING SYNCHRONIZATION

PHASE JUMP TECHNIQUE

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The parameters for synchronizing the booster bunch structure with the desired main ring bunch structure using the phase jump technique are derived in this note. The parameters provide for a rotation of 1/3 of a booster revolution to allow for synchronizing a gap in the booster with a given main ring gap. The assumed 500 KV voltage on the booster accelerating system presents problems in longitudinal phase space matching between the machines. This problem can be reduced by debunching in the booster by using an additional phase jump.

The wave forms involved are shown in the figure. Initially dB/dt = 0 and $\phi_s = \pi$. A 75° phase jump puts the bunch near the peak of the accelerating wave form and the radius program is adjusted to make $\phi_s = 105^\circ$. After 1/2 the desired phase shift the phase jump is reversed as is dR/dt. At the end of the period the energy and radius return to their initial values. The total phase shift is obtained by integrating the frequency program given by a constant energy gain per turn. It can be shown that this phase shift is given by:

$$\phi = T^2 \quad \frac{f^2 \gamma V q \sin(\pi - \theta)}{E_o(\gamma^2 - 1)h} \left(\frac{1}{\gamma^2} - \frac{1}{\gamma_T^2} \right)$$

For

$$\begin{aligned} f &= 5.3 \times 10^7 \text{Hz} \\ \gamma &= 11.7 \\ \gamma_T &= 5.74 \\ \Theta &= 75^\circ \\ E_o &= .938 \times 10^9 \text{eV} \\ Vq &= 5 \times 10^5 \text{eV} \end{aligned}$$

Then

$$\phi = 3.67 \times 10^7 \pi \, T^2$$

For

$$\begin{aligned} \phi &= 28(2\pi) \qquad T = 1.2 \times 10^{-3} \text{ sec.} \\ \Delta E &= 169 \text{ MeV} \\ \Delta R &= 3.6 \text{ cm} \end{aligned}$$

Since ΔE is proportional to TV and T is proportional to $1/\sqrt{V}$, E is proportional to $\sqrt{V}$.

Therefore the excursion in radius and energy could be reduced by reducing V but at the expense of increasing T. If the voltage is reduced to 2.5×10^5 then the parameters become:

$$\begin{aligned} T &= 1.7 \times 10^{-3} \text{ sec.} \\ \Delta E &= 120 \text{ MeV} \\ \Delta R &= 2.5 \text{ cm} \end{aligned}$$

It should be pointed out that the above excursions in ΔE and ΔR are required for any scheme that takes this short an interval.